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Foreword

New perspectives on meeting and mating

In this special issue, several authors have been invited in order to provide new perspectives on a set of phenomena related to sexual reproduction. The idea has been to offer a journey that explores sexual communication and mating practices in a wide range of animals, with a particular focus on the lesser-known model organisms as well as on recent and unexpected findings in well-established systems. As a result, the papers within this issue span a taxonomic range of organisms with a wide variety of mating systems. While this may seem rather heterogeneous, taken together this collection is intended to provide a more integrative view of sexual selection. The topics range from fundamental questions such as the diversity of processes targeted by sexual selection, to mate assessment, chemical communication and sexual conflict. As an ensemble these studies challenge some of the general assumptions, look beyond the traditional division of sex roles and place underexposed topics in the spotlight.

While the way in which sexual selection shapes the rich diversity of traits in the animal kingdom has been amply covered in the literature, there are many issues that are still worth investigating. The first four papers explore the formation of mating pairs. In this respect, animals produce a variety of signals to attract potential mates and such signals are generally species-specific and used to court individuals of the opposite sex. However, as pointed out by Adachi & Soma (2019) the process of pair formation does not necessarily lead to mating. The authors tackle the topic of sexual signalling in the light of same-sex pair formation. While examining the acoustic signals produced by Java sparrows, they observed that males establish pair bonds and exchange mating calls similar to those produced by male-female pairs. As they highlight, same-sex sexual behaviour is a widespread phenomenon in the animal kingdom, but its evolution and advantages clearly deserve further investigations.

The following contributions on mate choice and mating pair formation also provide food for thought. For example, Kaufmann & Otti (2019) add to increasing evidence that males gain fitness benefits by choosing among females, thus fostering the debate about the evolution and generality of male mate choice. In their experiment with bedbugs, they describe the importance of female body size for male mate choice. Female body condition also plays an important role in male reproductive decisions of scorpions (Olivero et al., 2019). Males of the investigated scorpion species perform sexual sting behaviour for a longer time with females that are in

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a better condition. These two studies also highlight that internal fertilization encompasses not only intimate contact between the two sexes (i.e., copulation *sensu stricto*; Zizzari et al., 2014), but also traumatic insemination where the sperm are injected directly into the body cavity of the female, as in bedbugs (Kaufmann & Otti, 2019), or indirect sperm transfer where the sperm are deposited on the substrate in spermatophores and subsequently picked-up by the females, as in scorpions (Olivero et al., 2019).

While the preceding two studies focus on species with unusual modes of sperm transfer, these organisms still have the conventional sexes, namely males and females. The paper by Lorenzi et al. (2019) focusses on a situation where both sexes are present in the same individual, i.e., simultaneous hermaphrodites. Specifically, they used an experimental approach to investigate the long and complex precopulatory behaviour used by a polychaete worm to make its decision about the sexual role to adopt. By analysing the worms' behaviour, the authors conclude that both partners share a preference for the same sexual role, which confirms that a conflict of interest between the sexes also exists in simultaneous hermaphrodites.

As already mentioned in the above, choices about mating and reproductive investment require detection of the relevant sexual signals, and the following two papers in this issue address this. Sexual selection is of course known to act on phenotypic traits involved in mate choice, but what about the receptor organs that receivers use to assess signallers? Elgar et al. (2019) draw upon what they refer to as Darwin's neglected idea that sexual selection may favour sexual dimorphism in antennal size. They combine this with empirical evidence that pheromone detection is linked to antennal morphology. A critical point made in their paper is that male antennal size and shape indeed evolve through sexual selection since more elaborate antennae show greater sensitivity to female sex pheromones.

Clearly, sex pheromones are particularly important for animal reproduction. They are not only a primary means of contact between mates, but also mediate mate assessment. Hence, the special issue includes an opinion piece by Groot & Zizzari (2019), discussing the effects of climate warming on species sexual chemical signalling. The authors point out that in the ongoing rapid growth of research on the consequences of extreme temperature events, it is surprising that no studies have yet addressed whether and/or how animals are able to adapt their pheromone perception and signalling to thermal stress. They highlight that the scant work conducted in this direction so far indicates that chemical communication between sexes can be impacted, and that this can have as yet unknown consequences for sexual selection.

The last two papers that follow these contributions, which all focussed on precopulatory sexual selection, are more concerned with the post-copulatory processes, taking different perspective. From the male perspective, mating can be costly in terms of ejaculate transfer, which partly links back to the issue of male mate choice mentioned earlier, because males might decide to tailor their sperm transfer according to their mate's mating history. However, in order to understand such decisions, it is also important to know how sperm is transferred within a single copulation. As

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Weggelaar et al. (2019) point out this turns out to be another often-overlooked aspect of post-copulatory sexual selection. It is generally assumed that the relationship between copulation duration and number of transferred sperm is linear. Interestingly though, as they discuss, this is not always the case. The authors present an experiment where they demonstrate that a freshwater snail transfers its sperm in a clearly non-linear fashion. Additionally, they then review the literature on the topic and highlight how the different types of relationships between copulation duration and number of sperm are distributed across the animal kingdom. Overall, they offer a novel perspective, suggesting that using copulation duration as a proxy for the number of sperm transferred might be misleading.

While males benefit from an increased number of matings, it becomes evident from the paper by Oku et al. (2019) that mating multiple times can be costly for females, especially in polyandrous species. Incoming sperm, accessory gland products and/or physical harm induced by the partner can challenge female immunity. To avoid excessive mating costs, female counter-adaptations are likely, and one route would be to use immune defence against the foreign material. Because there are relatively few studies on this topic, the authors provide a review of the effects of mating on female immunity in insects and discuss that female resistance is reduced in some taxa and increased in others. The authors highlight that further studies should address the link between female immunity and mating in different mating systems, to assess whether polyandrous females have indeed evolved post-mating immune resistance.

In conclusion, although clearly this special issue is far from exhausting the list of novel advances and unresolved topics in the broad field of animal reproductive behaviour, it does demonstrate that there is still much that needs to be uncovered about the evolution of animal mating systems and sexual interactions. Moreover, besides contributing to fundamental understanding of sexual reproduction processes and their evolution, it also points out more applied implications of such findings. The authors of the papers published in the issue have identified significant questions that will undoubtedly stimulate additional research on the diversity of sexual reproduction and mechanisms of sexual selection.

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